Negotiating the forest - farmland interface in northern Thailand with companion modelling[1]

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Abstract

The debate about the expansion of agriculture in forest areas and the conservation or reforestation of head watersheds is still going on in montane Southeast Asia but in a rapidly changing context. Tremendous change occurred in the highland agrarian systems of northern Thailand during the past decades, leading to new farming practices, an increased diversity of stakeholders concerned by land management issues, and new relationships between villagers and national policies (decentralisation of resource management, shift from forest exploitation to conservation, etc.) and international conventions. In this context, the debate about the true participation of rural people in managing local renewable resources is taking central stage.

New conceptual and practical tools to understand rural change in a more distributed, inclusive and interactive way have also emerged. System approaches relying on collaborative modelling are used to facilitate communication, knowledge sharing and the exchange of points of view among different types of stakeholders about a common resource management problem. The iterative and evolving Companion Modelling (ComMod) approach relies on multi-agent systems and makes use of the synergistic effects between role-playing games and computer agent-based models to co-construct simulation tools with stakeholders used in the joint exploration of possible future scenarios of their choice as part of negotiation processes leading to concrete action plans.

In the past three years, such a ComMod process has been implemented in the head watershed of Nan province to understand the effects of recent change in forest management on the agrarian system and to mediate a land use conflict between foresters and Hmong herders. A preliminary diagnostic-analysis showed the influence of increased forest conservation efforts on the dynamics of deforestation in the local Hmong agrarian system. These land use dynamics were represented in a spatially explicit computer-assisted role-playing game. This tool was enriched and validated with the herders and foresters during a first set of gaming and simulation sessions aiming at the production of a shared representation of the problem at stake. The debate that followed identified innovative cattle management techniques to be tested and the simulation tool was modified to accommodate them. A second set of collaborative simulations tested the use of these innovations and led to an agreement on a joint experiment between herders and foresters seen as a first concrete step toward the co-management of the local forest –farmland interface.

These results are discussed and the relevance of the approach, as well as the strengths and limitations of its main tools are assessed. Finally possible methodological improvements are suggested for collaborative modelling and simulation to better support the emergence of effective decentralized co-management of renewable resources in similar socio-ecological systems.

Key words: Forest conservation, land use change, highland agrarian systems, Companion modelling, agent-based modelling, role-playing game, north Thailand.

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Introduction

During the past four decades, the expansion of farm land in forest areas of montane Southeast Asia accompanied the commercialisation of upland and highland agriculture (Trébuil et al. 2006). For political and economic reasons, this agrarian transformation started earlier in Thailand but is also occurring in neighbouring countries. Deforestation occurred at a rapid pace in the 70s and continued at a more moderate rhythm during the following two decades. The interdependent major driving factors and related causes of this sharp decrease of forest cover were the promotion of logging concessions, counter insurgency measures like the construction of feeding roads bringing new settlers, especially from the lowlands, and facilitating the expansion of farm land and market integration of farms leading to a jump in the production of rainfed field cash crops such as maize, soybean, cassava and sugarcane (Delang 2002, Trébuil 2000). The country farm land area jumped from 17.9 to 21.3 million hectares between 1975 and 1991 (OAE, 2000) and remained relatively stable afterwards, while the forest cover decreased from 20.9 to 13.6 million ha (RFD, 2009) during the same period. In the words of Sato (2000), this peasant colonization process, in which many lowlanders took part, led millions of rural households to make a living on 'ambiguous lands' which are lands 'legally owned by the state but... used and cultivated by local people' especially along the forest - farm land interface.

The social context changed in the late 80s and early 90s with the rise of strong environmentalist protests supported by a booming middleclass, partly triggered by a major deadly landslide in the southern region, claimed to be a result of deforestation that ushered a nationwide government logging ban in 1989 (Delang 2002, 2005). During the previous decades, the Royal Thai Government (RTG) policies regarding forest management have been enforced through top-down policies implemented by the Royal Forest Department (RFD) created more than a century ago. Following decades of management of forest exploitation and logging activities, a new focus on forest conservation was declared during the last two decades in an attempt to reverse the trend of deforestation and forest degradation and to cope with new international conventions and global environmental concerns linked to biodiversity, climate change and carbon sequestration, etc. During this period, the transformation of various types of swiddening systems practiced by diverse ethnic highlanders toward more permanent and market-oriented agricultural production systems continued, with annual and low input cash crops being partly replaced by a range of perennial crops such as fruit orchards, tea gardens, rubber plantations, etc. (Kaosa-ard, 2000; Lakanavichian, 2001, Trébuil *et al.* 2006). Nevertheless, more intensive state control of forests led to a sharp increase in the number of "reserved forest areas" established by the RFD. The total area covered by national parks, forest parks and wildlife sanctuaries increased from 5.9 to 8.9 million ha during 1990-2004 and more have still to be officially declared (Royal Forest Department, 2009). But a large proportion of these "forest reserves" were already under cultivation and the way these conservation areas were created led to land use conflicts between the local farming communities and the representatives of the government agencies in charge of their delimitation and management. The two sides had very different objectives regarding land and forest use and contrasted perceptions about the impact of these forest conservation areas on local people livelihoods, while most of the time no mechanism was established to discuss them (Hares, 2009; Roth, 2008; Sato, 2000).

With the establishment of the Tambon (sub-district) Administration Organization (TAO) system in 1994, the RTG has launched a process of decentralization of the management of local resources and improvement of local people rights. For example, a community forest bill was recently passed after many years of debate. This new legal and institutional framework could provide an opportunity to ethnic minorities to voice their needs and truly participate in renewable resource management. This brief description of the recent evolution of land management in northern Thailand shows that the analysis of the dynamics at the agriculture – forest interface needs to be framed within the context of agrarian change as the orientation of the livelihoods of those who live in or near forests depend considerably on a rapidly changing agriculture and become more diverse (Fisher and Hirsch 2008). As an increasing number of critical issues need to be examined at the interface between the environment and society, it also describes a situation adapted to the assessment of the impact of forest conservation and reforestation measures on local agrarian systems, and to the search for adapted ways to mitigate the increasing number of local land use conflicts while facilitating the true participation of village communities in the management of local renewable resources.

This paper reports and discuss the results of a participatory modelling process implemented in the head watershed of Nan province to facilitate the mediation of a land use conflict between Hmong herders raising cattle in fallows and secondary forest areas and government agencies in charge of reforestation activities and the establishment of the new Nantaburi national park (NNP). Following a characterization of the study site, the main phases of the collaborative process and the tools used are described and the key results are presented. A discussion section draws lessons from this experiment and suggests possible methodological improvements toward a more effective use of gaming and simulation tools to facilitate the emergence of co-management of resources in similar socio-ecological systems facing land use conflicts.

Materials and methods

Agrarian system and stakeholder analysis

The history of interactions between rural societies and their natural environment leads to understand the origins, causes and consequences of landscape transformations and the differentiation of livelihoods and agricultural production systems depending on their access to productive resources, regulation rules and institutional control (Mazoyer and Roudart, 1997). Interdisciplinary knowledge at the interface between socio-economic and agro-ecological dynamics is needed to interpret land use change. Key past events, forces, trends, power relations dynamics, and the respective needs of different individual or institutional stakeholders are revealed and can be used to design better ways to manage the landscape. Lambin *et al.* (2003) proposed integrated frameworks and related tools to understand the causes and relationship of driving factors of land use change: agent-based perspective relies on the individual decision making and motivations behind it, while a system perspective looks also at the organization and institutions of the society, and a narrative perspective favours depth of understanding through historical details. The agrarian system[4] diagnosis methodology combines such frameworks to produce dynamic agro-ecological zoning linked to an historical agrarian profile and the construction of typologies of local stakeholders based on their different socio-economic objectives and strategies (Trébuil and Dufumier, 1993). This methodology was used in this case study to understand the effects of forest management on farming and the origins of the current land use conflict as well as to characterize its key actors.

The companion modelling approach

The outputs from this agrarian system diagnosis and stakeholder analysis were used to design an interactive and inclusive Companion Modelling (ComMod, http://www.commod.org) process to examine the land use conflict with its main actors and improve communication among them (Barnaud *et al.* 2008). During the past decade, such processes have been used by researchers and local stakeholders to co-construct shared representations of given complex issues, and to use them to explore possible solutions of their choice through collaborative simulations. The scientific posture of the ComMod researcher creates an original relation between him, the models he develops, and the field actors and circumstances. By considering him/herself as part of the system being managed, in such engaged research processes the researcher is a stakeholder among others (Bousquet *et al.* 2005). Because most of the current problems in agrarian systems are complex, rapidly evolving, and need to be addressed in more uncertain and unpredictable

[4] Agrarian system is defined as a historically constituted and lasting model of exploitation of the environment, a technical system adapted to the bioclimatic conditions of a given area which complies with its social conditions and needs at that moment (Mazoyer and Roudart, 1997).

environments, the main objectives of a ComMod process are (i) to better understand a complex agro-ecosystem through the collaborative construction and joint use of different types of simulation models integrating various stakeholders' points of view, and (ii) to use these models within communication platforms for collective learning to facilitate multiple stakeholders' coordination and negotiation processes leading to the definition of agreed-upon collective action plans.

The ComMod approach focuses on the management of interactions between ecological and social dynamics by relying on the Multi-Agent Systems (MAS) way of thinking. Most of the ComMod processes associate computer agent-based models (ABM) with Role-Playing Games (RPG) in various ways to facilitate the involvement of stakeholders in the co-design and use of evolving simulation tools (Ruankaew *et al*. 2010). The ComMod approach did not emerge from theoretical debates among researchers but from common problems faced in empirical research dealing with complex objects of study, but several key theoretical references of this integrative modelling approach (the science of complexity, resilience and adaptive management, multi-actor processes, constructivism, post-normal science) are presented in Trébuil (2008). In practice, a ComMod process alternates modelling in the lab. and field activities in an iterative way. Successive participatory modelling field workshops lasting 2 to 3 days are key moments of intense interactions among the participants, alternating gaming and simulation sessions and plenary debates, and completed by individual interviews at the end to better understand decisions made in the simulations and gather suggestions for the next steps. During these workshops the process facilitator's hypotheses, methods and tools are systematically made explicit, regularly questioned, critically examined, and adapted to stakeholders' needs and change in the context.

Study site

Doi Tiew village, a highland (900-1200 m above mean sea level) forest-farmland ecosystem located in a headwater area northwest of Tha Wang Pha District in Nan Province, was selected as it is established along the border of a recently declared national park and is also affected by government-led reforestation activities. Figure 1 shows that this Hmong farming community, who settled in this area in 1961, is presently almost surrounded by several government forest conservation agencies including several reforestation units (the Nam Khang Headwater Study Development and Conservation Unit –NKU- and Sob Sai, Nam Haen, and Nam Ngao Headwater Management Units) and the newly established Nantaburi National Park (NNP). In 2007, Doi Tiew had 1,307 inhabitants belonging to 170 households scattered along 2 km of the main asphalted road. The current main farming activities are upland rice production for home consumption, maize and litchi as key cash crops, and extensive cattle rearing in grasslands, fallows, and young forest plantations. But these agricultural activities, particularly cattle rearing, are increasingly constrained by the local forest management ones as NKU and NNP are increasingly limiting the extent of grazing areas available to local herders.

Overall conceptual framework

Figure 2 displays the overall conceptual framework used in the implementation of the research activities. The outputs of the preliminary multi-scale agrarian system diagnosis (complementary analyses of land use change at the landscape level, socio-economic differentiation among farms at the household level, and vegetation dynamics under the influence of reforestation and cattle rearing activities at the plot level) provided knowledge for the construction of a first conceptual model of the sub-system to be managed by herders and foresters. It was improved through a series of ComMod activities based on the use of successive versions of a computer-assisted RPG in field workshops, leading at the end to the construction of an autonomous ABM simulator allowing to explore more scenarios in a more cost effective way and to out-scale the findings.

Main phases of the ComMod process implemented at Doi Tiew site

Figure 3 presents a detailed account of the 3 sequences of the ComMod process and their outputs.

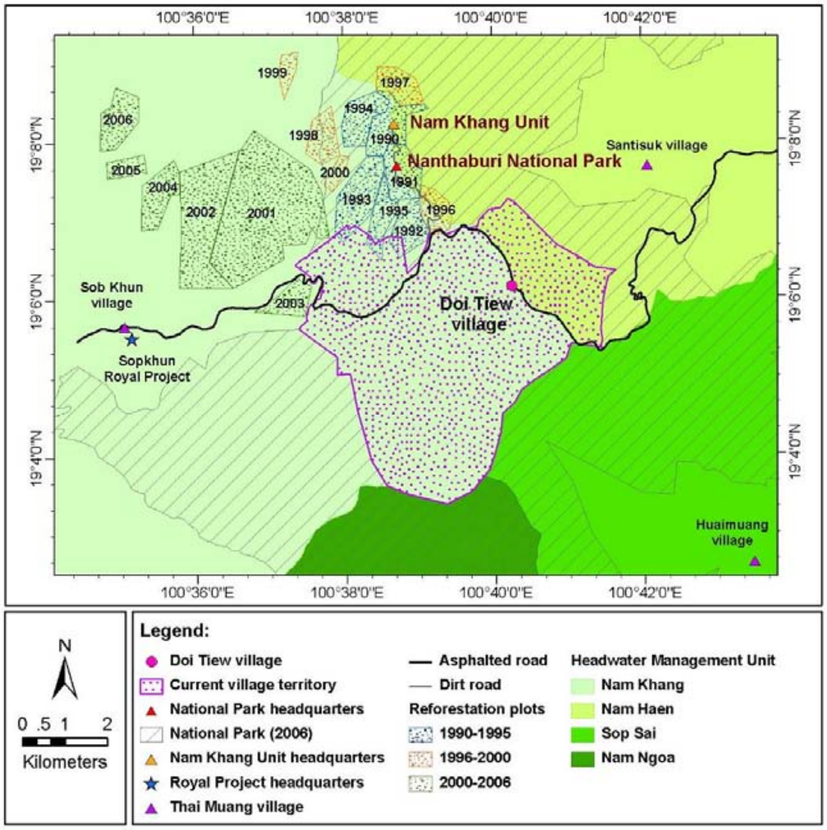


Figure 1. Doi Tiew village and of its neighbouring forest management agencies in Tha Wang Pha district, Nan Province, Northern Thailand.

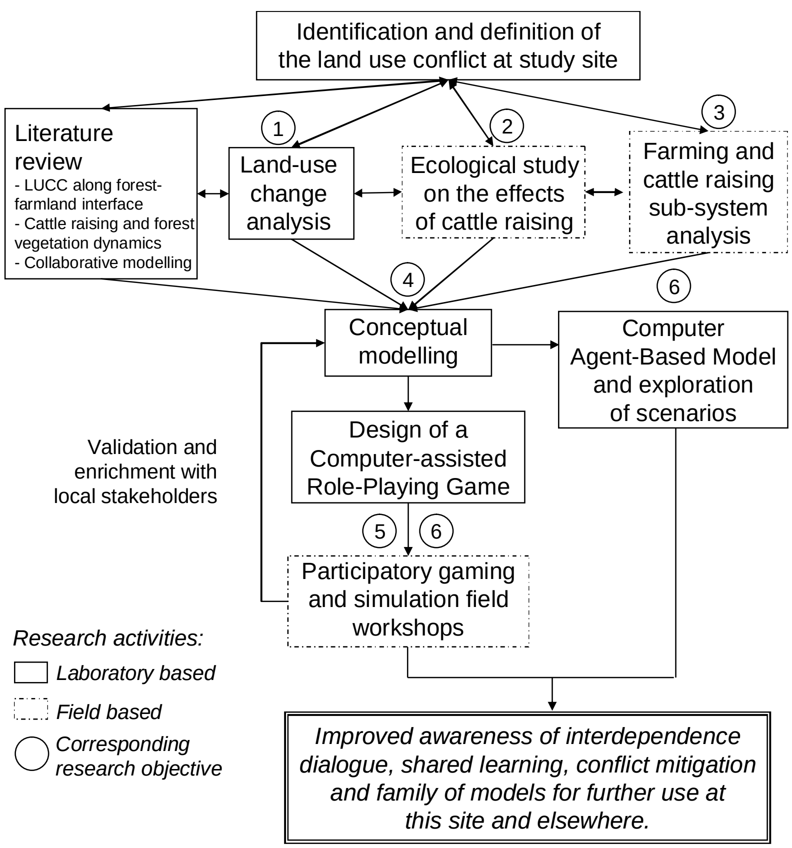
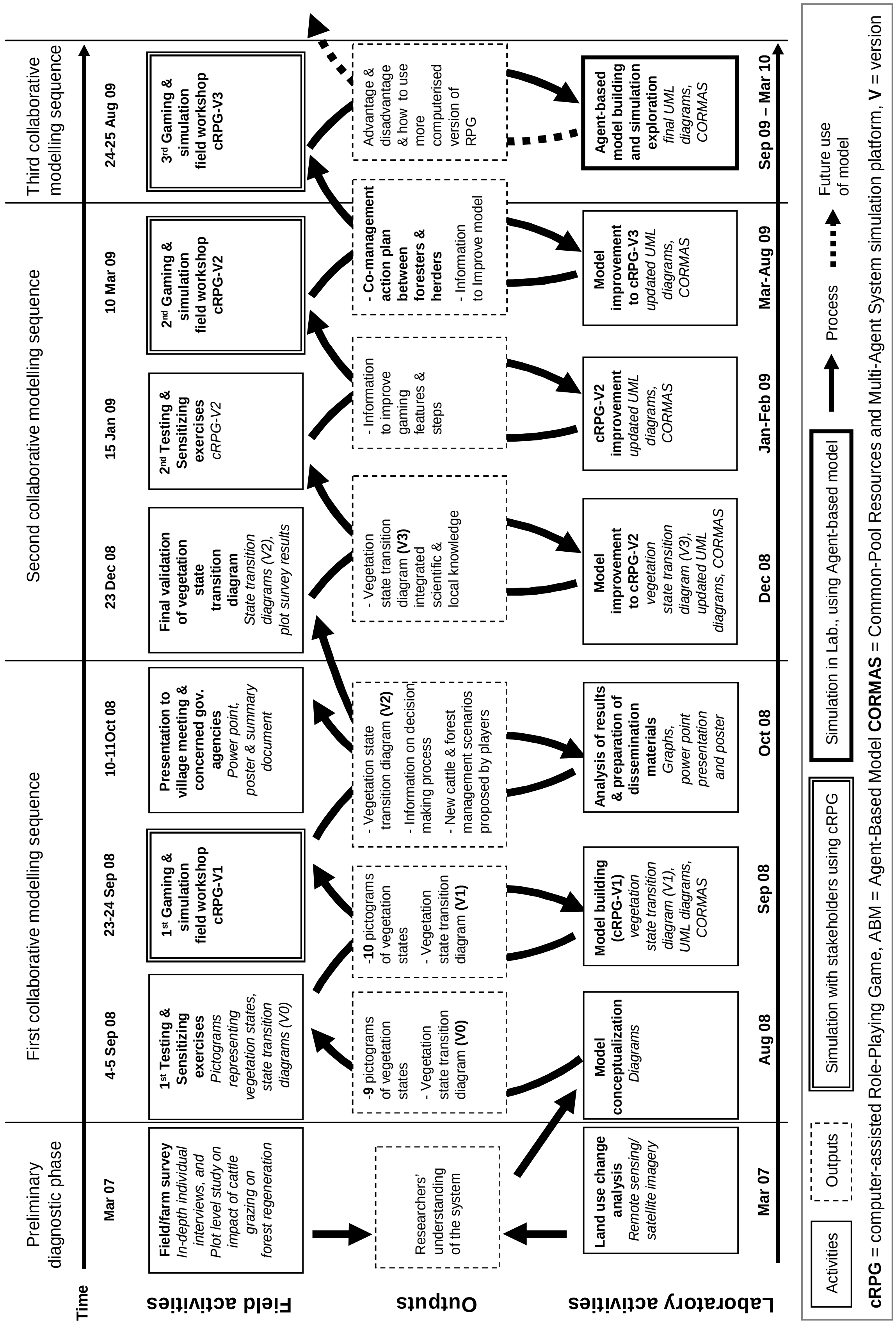


Figure 2. Conceptual framework of the research associating an agrarian system analysis and a companion modelling process.

Figure 3. Successive phases of the ComMod process implemented in Doi Tiew village of Nan Province, Northern Thailand, 2007-2009.



Results

Recent land use change and agrarian transformations explaining the current conflict

Table 1. Recent transformations of Doi Tiew agrarian system, 1961-2008.

Variables	1961 - 1980	1980 - 1990	1990 - 2008
Ecological system	- Scattered agricultural area inside the dense forest cover	- More forests encroachment in the southern part	- Clear separation between conservation and farm land - More encroachment on steep land
Technical practices	- Manual techniques - Long fallow period of up to 12 years	- Using handheld machines, i.e. sprayer - Fallow period became shorter at 5 - 8 years	- Short fallow period of 2-3 years, permanent cultivation on some very small holdings - Heavy machinery (trucks, rice mills)
Cropping systems	- Upland rice for home consumption - Opium poppy for sale	- Maize for animal feed is the main cash crop - Upland rice for home consumption - Introduction of litchi as intercrop in maize or rice fields	- Upland rice for home consumption - Litchi becomes the main cash crop. Some farms close to the stream are irrigating their orchards
Livestock rearing system	- Poultry - Cattle raising in natural forest for own consumption, savings & ceremonies	- Poultry - Cattle raising in natural forest for animal sales more than savings	- Poultry - Cattle raising in natural forest, reforestation areas and fallows for animal sales and savings
Non – timber forest products	- Bamboo shoots, mushrooms, other edible vegetables, hunting animals (wild boar, birds, etc.), medicinal plants, palms for roof making, woods/bamboo for house construction		- More limited in what can be harvested due to government laws - More important to poor households for own consumption
Demo - graphic pressure	- Low (~50 HH, ~200 inhabitants.) - Farm land for illegal occupation easily available	- Medium (~100 HH, ~500 inhabitants) - Suitable farm land almost occupied by early immigrants from the lowlands	- High (~170 HH, 1,300 inhabitants in 2007) - Smaller holdings inherited from parents, expansion of agricultural area not allowed by law
Access to market	- Low, mainly through opium poppy activity	- Medium in earlier phase and high in late phase due to more experience and connection with lowland farmers and merchants	- High, due to good transports and telecommunication infrastructures - Farmers can negotiate prices or select among traders before sales
Inputs	- No external inputs	- External inputs are used: start using fertilizer on maize, for handheld machines, etc.	- Higher use of external inputs: fertilizers, pesticides, herbicides, and for heavy machines
Rural credit	- None	- Farmers borrow from neighbours in the same clan and without interest rate	- Plus loans from the village fund, Bank for Agriculture & Agricultural Cooperatives with low interest rate
Land tenure	- No land title due to the location of village is in headwater area (class 1A watershed) - Land occupation is illegal but farmers pay a tax to the government		
Labour market	- From households and through mutual help		- Decrease of mutual help - Hired labour from the village at maize and litchi harvesting - Start working off-farm in town
Agricultural incomes	- From opium poppy	- 50% from maize & cattle, unless own a large herd	- From sales of litchi and maize more than cattle
State intervene-tions	- 1965 – 1972: counter insurgency against the Communist Party of Thailand - Villagers moved to lowlands areas	- Development projects from government agencies : new crops to replace opium poppy and reduce shifting cultivation	- 1990: reforestation policy implemented by establishing the Nam Khang Headwater Development and Conservation Unit - 1996: implementation of forest conservation policy, establishment of the Nantaburi National Park - Villagers attempt to negotiate the park boundary with the manager - 2006: manager decided to cut - off 46% of the initial size of the park
Socio-economic differentiation	- Not much differences among households	- Early settlers accumulate farm land and cattle - Diverse types of farming HH appear	- More diversity of farm types based on available farm land, cattle assets and investment capacity

Table 1 summarizes the findings from the agrarian system analysis and provides an historical explanation of the current forest and farming situation. In particular, in relation to the cattle raising activity, four types of farms can currently be found in the village as shown in figure 4.

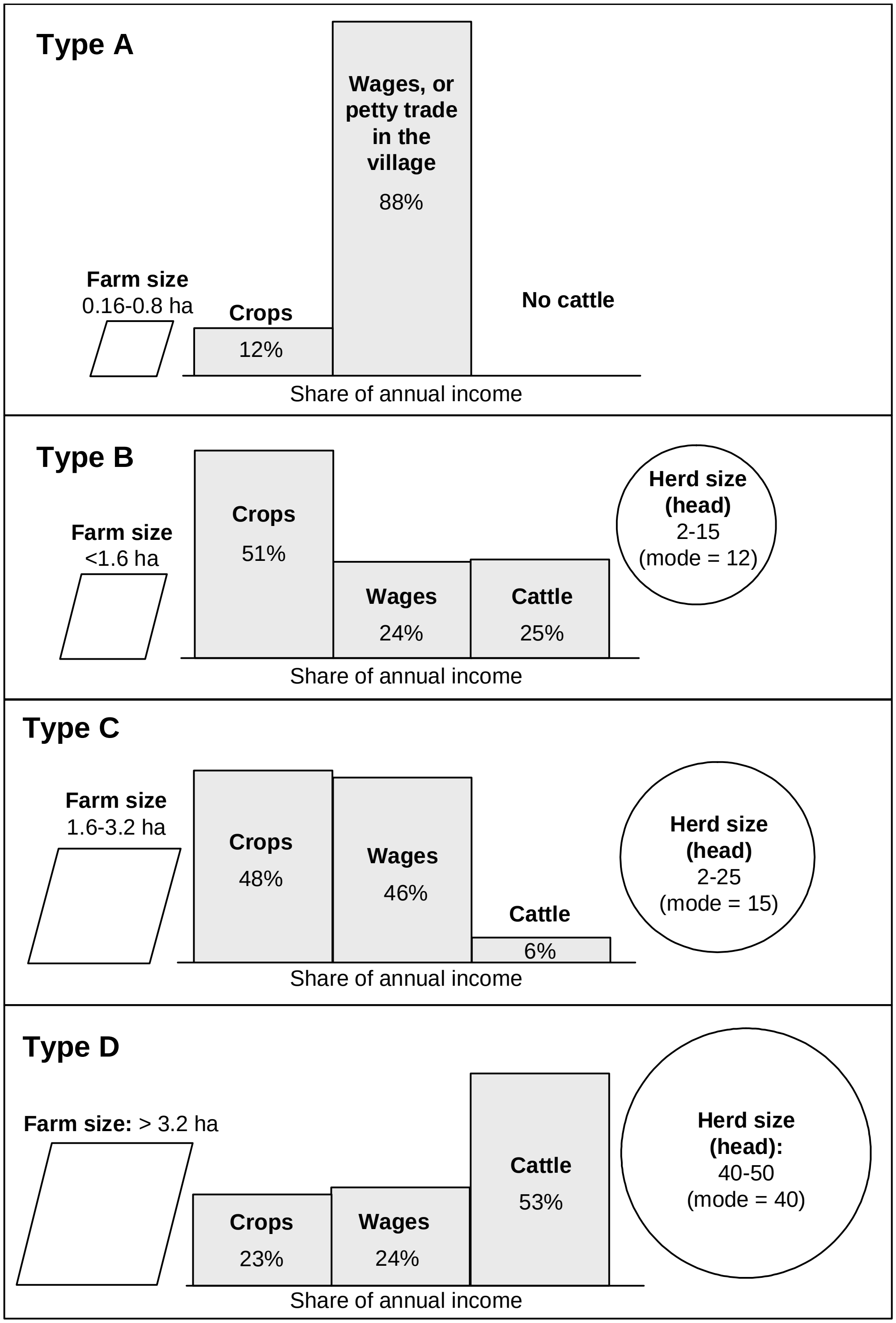


Figure 4**.** Farmer typology of Doi Tiew village in relation to cattle raising. Farm size, herd size and composition of annual household income for 2007 crop year.

Reaching an agreement on vegetation dynamics

The preliminary ecological survey at the plot level provided a sound dataset to represent the local vegetation dynamics. The research team assembled its knowledge in a first state transition diagram submitted to herders and foresters who modified it based on their empirical and expert knowledge. The modified diagram used for coding the first version of the computer-assisted RPG (CRPG-V1), the main tool in the first gaming and simulation workshop, is shown in figure 5.

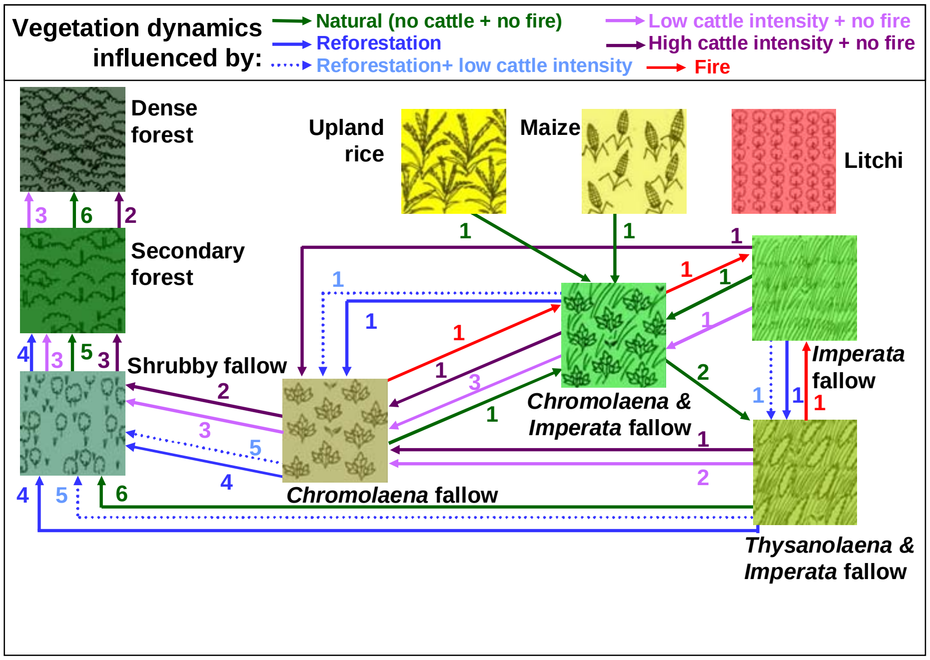


Figure 5. Vegetation state transition diagram used for coding the 1st version of the agent based model.

A co-designed gaming and simulation interface at the landscape level

To visualize vegetation dynamics at the landscape level, a transect of the 2003 land use map of the area was selected and simplified to make it more abstract while retaining the actual gradients and diversity of land cover classes as shown in figure 6 (Dumrongrojwatthana *et al*. 2009).

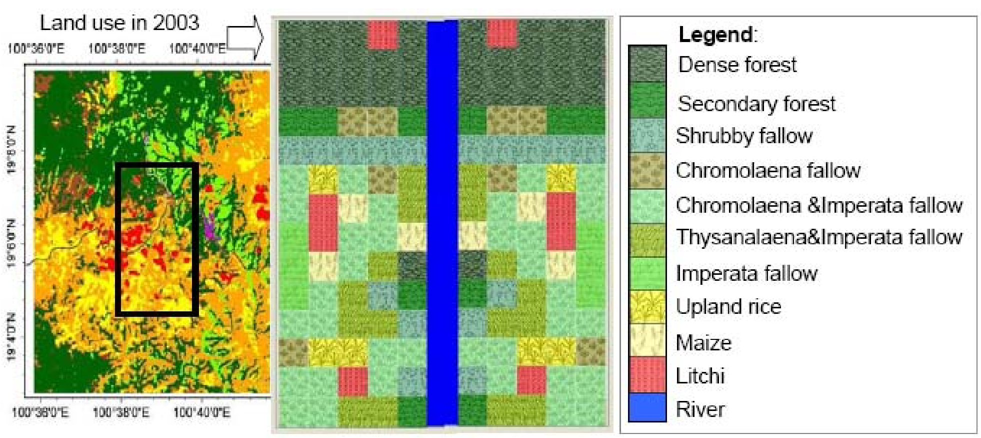


Figure **Error! No text of specified style in document.**. The spatial interface of the first version of the computer-assisted Role-Playing Game used with Doi Tiew villagers in Nan province (green shade = forest, yellow shade = farm land).

The same set of pictograms used in the vegetation state transition diagram was used and the virtual landscape was made symmetric to facilitate the visual comparison of the results of contrasted land management strategies used by two (left and right) groups of players.

Results of the first ComMod sequence and participatory modelling sessions

Table 2 describes the first workshop implemented with the stakeholders to produce a shared representation of the interactions between cattle rearing and reforestation activities in the area.

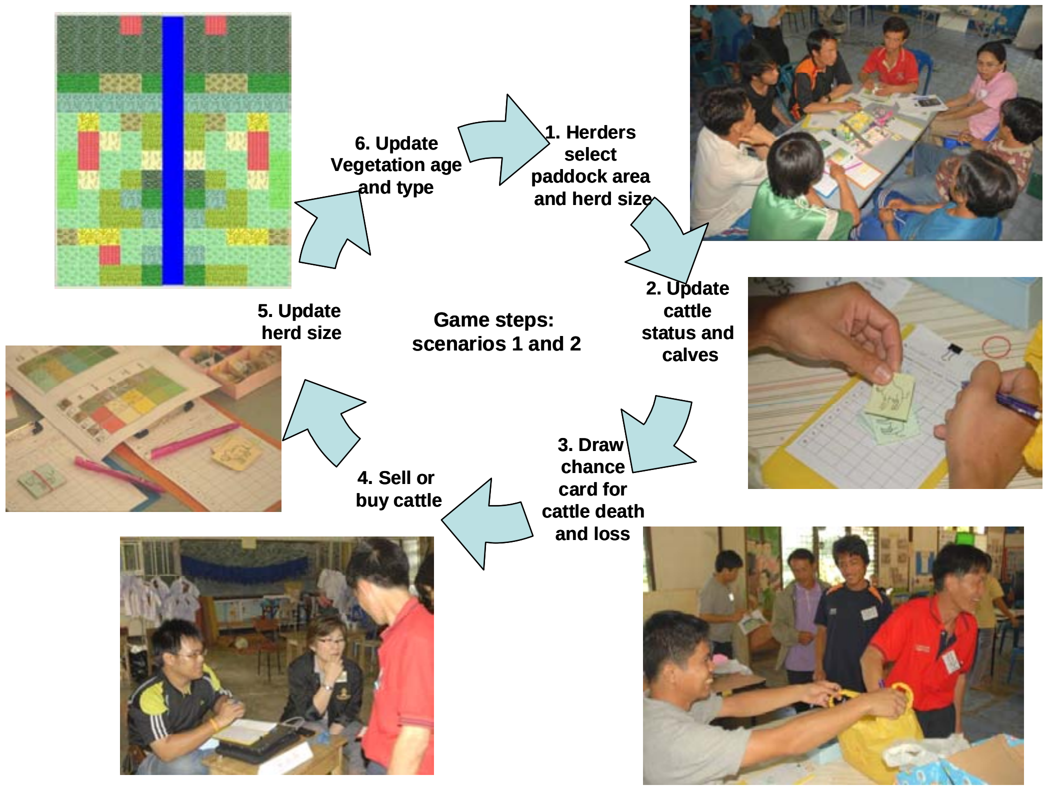
Table 2. Description of the first participatory gaming and simulation field workshop.

Activity	First test	Gaming and simulation (G & S) workshop			
	4 - 5 Sep 09	23 Sep 2008		24 Sep 2008	
		Day 1 - am	Day 1 - pm	Day 2 - am	Day 2 - pm
Location	District Office	Doi Tiew School		District Office	
Objectives	- To test a gaming tool based on researchers' understanding of vegetation dynamics. - To understand stakeholders' perceptions of these dynamics. - To sensitize a small group of stakeholders before participation in a G & S workshop.	- Introduction of the gaming tool to newcomers (similar activity to sensitizing exercise). - To explore with herders what needs to be modified in the researchers' representation of the system.	- To investigate herders' decision - making process and interactions regarding cattle rearing and forest regeneration. - To prepare the herders to participate in G & S sessions with foresters by giving them more time to understand the G & S tool.	- To present day 1 - pm results to foresters and show how the cRPG works. - To demonstrate how the cRPG works without entering players' decision on cattle raising and reforestation.	- To investigate the foresters' and herders' decision - making processes and interactions. - To stimulate communication, collective learning and sharing of knowledge and perceptions between herders and foresters.
Types of participants (number)	- NKU foresters (4) - Herders (5) - Researcher (1) - Assistant (1)	- Herders (13) - Researchers (4) - Assistants (7)	- Herders (14) - Researchers (4) - Assistants (7)	- NKU foresters (3) - Herders (8) - Researchers (3) - Assistants (7)	
Main tool used	- Pictograms of possible vegetation states based on transition diagram proposed by researchers (V0)	- RPG using pictograms of vegetation states	- cRPG - V1	- Power point presentation of day - 1 results - Simulation in cRPG - V1, no human decision)	- cRPG - V1
Scenarios (number of rounds simulated) & activity	- Vegetation dynamics affected by different factors (cattle density, fire, etc.) - Discuss and agree on vegetation state transitions with foresters and herders, separately	- Herders indicate the next vegetation state based on given cattle number and paddock size.	- S1 (3 rounds): 2 groups of herders manage cattle, no reforestation plots. - S2 (1 round): 2 groups of herders manage cattle with reforestation plots of different ages located in landscape by researchers.	- S3 (10 time steps): demonstration of vegetation dynamics with reforestation plots and without cattle in the landscape.	- S4 (4 rounds): herders and foresters manage a common landscape, negotiation is allowed, and different age of reforestation plots set in landscape sheet by foresters.
Expected Outputs	- Vegetation state transition diagram produced by herders and foresters - Information to design the gaming and simulation tool and features	- Updated vegetation state transition diagram (V2) with larger group of participants	- Herders' understanding of the gaming tool and features - Improved communication among herders	- NKU foresters' understanding on how the G & S work and decision	- A shared representation on forest regeneration - Improved communication among them - Suggestions on how to improve the process.

The computer module of the cRPG-V1 main tool used in this workshop was in charge of updating the vegetation cover of the virtual landscape after each round of play by applying the transition rules of the figure 5 diagram, based on the land and cattle management decisions made by the players (choice of reforestation plots, delimitation of paddocks, selected grazing pressure, etc.).

The activities of this sequence showed that both the herders and foresters were able to use their own knowledge to understand the vegetation dynamics displayed in the gaming sessions and to manage the proposed virtual landscape by following the steps displayed in figure 7.

Top: day 1 with herders only



Bottom: day 2 with herders and foresters

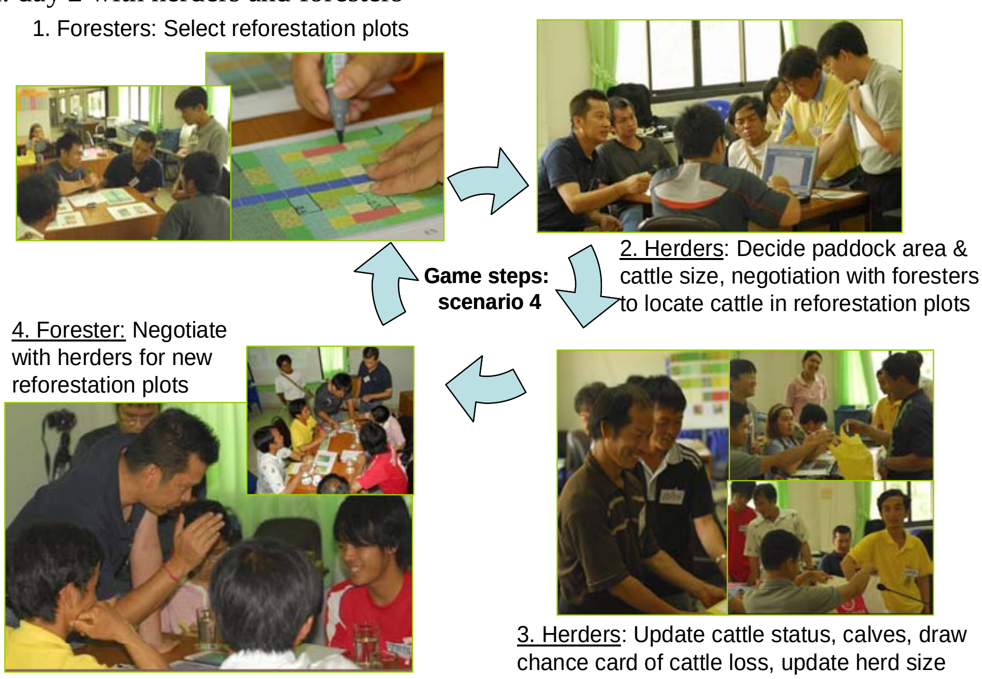
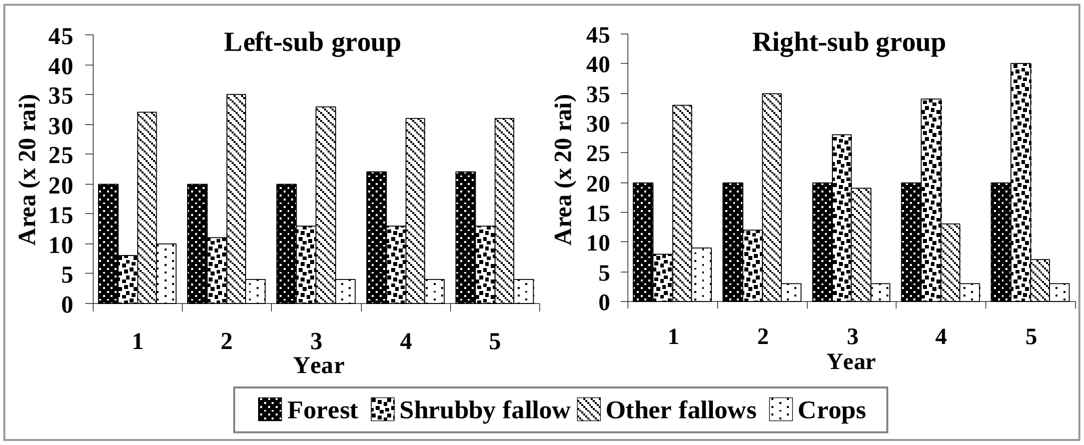


Figure 7. Main steps of a round of play for scenarios 1, 2 with herders only (top), and scenario 4 with herders and foresters (bottom) in the first gaming and simulation workshop.
Figure 8 displays an example of the simulation results of a scenario showing a gradual decrease of the area suitable for cattle grazing. Over time, while foresters had more difficulty to find new plots for tree plantations, herders found less and less grassy fallows for their herds.



Note: Forest = Dense forest + secondary forest cells; Crops = Upland rice + Maize + Litchi cells

Figure 8. Vegetation dynamics during the simulation of a scenario with two groups of herders and one group of foresters managing the same landscape (scenario 4) in the first gaming and simulation workshop.

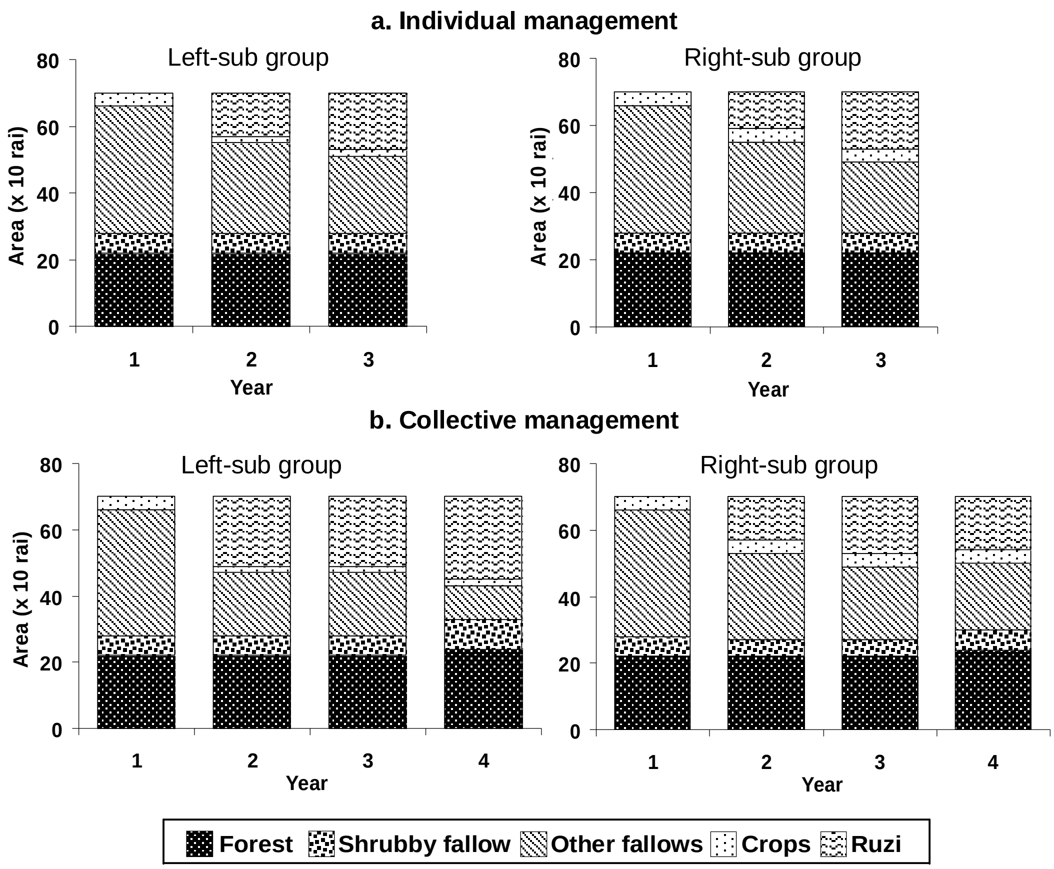
In the plenary debate that followed the simulation sessions at the end of this first ComMod sequence, the herders and foresters agreed on the need to introduce new cattle rearing techniques based on artificial pastures of Bracharia sp. (ruzi grass) and paddock rotations. They requested the research team to modify the cRPG-V1 tool accordingly to be able to simulate the landscape dynamics with these innovations in place.

Results of the second ComMod sequence and set of participatory modelling sessions
A similar set of activities than in the first sequence was implemented with the cRPG-V2 modified simulation tool (for more details see Dumrongrojwatthana 2010). Several time-consuming steps of the game (such as updating herd size after each year / round of play and the cattle status – fat, normal or thin- depending on the satisfaction of their forage needs) were also managed by the computer in this new version. It was calibrated to be played with 6 herders, several foresters and NNP rangers as the NNP boundary and management rules were also implemented in this 2nd version of the simulation tool.

Following a first sequence focusing on understanding and agreeing on the simulated sub-system, the second sequence of activities aimed at facilitating collective decision making on landscape management. Therefore, the objectives of the second field workshop were (i) to assess the effects of *ruzi* pastures and paddock rotations on land use and land cover dynamics, and depending on the results (ii) to use collaborative simulations to support the negotiation of an action plan for the co-management of the forest-farmland interface by the local stakeholders.

After simulating the effects of different modes of communication among them on land use dynamics, herd size and cattle status, the herders learned that the collective management of their herds allowed a more extensive establishment of *ruzi* pastures as seen in

. In the subsequent plenary debate, the herders and foresters agreed to implement a joint experiment on 10 ha of land provided by NKU in order to test the feasibility of such cattle management techniques in actual circumstances. The District livestock officer who observed the proceedings agreed to provide the *ruzi* seeds and was asked by the herders to witness the implementation of the agreed upon action plan between them and the foresters.



Note: Forest = Dense forest + secondary forest cells; Crops = Upland rice + Maize + Litchi cells.

Figure **Error! No text of specified style in document.**.1. Land use dynamics according to two modes of communication among herders simulated by two groups of herders in the second field workshop.

Discussion

Improved communication and trust between herders and foresters

These two initial sequences of the ComMod process were successful in improving dialogue, knowledge sharing and exchange of perceptions on landscape dynamics between the parties in conflict. The initial diagnostic activities played an important role in the preparation of the following ComMod activities as the diversity of stakeholders, their different strategies and power relations had to be taken into account. For example such information was needed to select the participants invited to take part in the first sequence and, depending on the results, to manage a suitable evolution of the stakeholders' arena in the following ones. Because the level of trust between the tow main parties is not high yet, district officers were called by the herders to witness the proceedings and monitor the implementation of the agreement.

The use of tools easy to understand by the Hmong herders (but not too much realistic to encourage creativity), the transparency of the methodological choices made, and the increasing influence of the users on the characteristics of the simulation tool and the focus of the proceedings led to a good involvement of the stakeholders in knowledge sharing and collective learning activities. At the end of the second sequence, the herders requested to train more villagers with the simulation tool to facilitate change in cattle rearing activities and the implementation of the action plan.

Key role of the process facilitator

This "human interface" is initially in charge of multiple tasks, such as assembling the knowledge base about the issue at stake, building the initial versions of the gaming and simulation tools, sensitizing the stakeholders about the proposed collaborative modelling activities and tools, establish and maintain dialogue among the parties in conflict, be adaptive and drive the process based on requests received from the participants, etc. Beyond the initial phases of the process in which the research team plays this multiple role, there is a need to train a local facilitator to be able to involve more stakeholders in the process and to monitor its effects. In the Doi Tiew case study, we observed that former players with a good understanding of the simulation tool were very efficient at training newcomers or disseminating the results of field workshops at village meetings. This is why a third ComMod sequence is being implemented to test the use of a more autonomous computer ABM (cRPG-V3) to facilitate such a farmer to farmer training process (for more details see Dumrongrojwatthana 2010).

Specificities of ComMod models

The Doi Tiew case study illustrates the production of a series of evolving models and simulation tools along a ComMod process. There is no *a priori* attempt at making more and more sophisticated tools and frequently simple models are effective ones. Successive versions of the simulation tools can be used to describe the evolution of the process based on shifts of focus made by the participants. In the early phases, these models are usually used to integrate knowledge from various sources and to facilitate the exchange of points of view. Later on, they play a crucial role in supporting negotiation and collective decision-making. Much flexibility of the modelling framework is needed to be adaptive to the stakeholders' requests and multi-agent systems offer suitable simulation platforms to do that.

Diversity of effects on the participants

The main immediate effects observed on the participants in the Doi Tiew case study so far are threefold. There is an increased awareness of the herders of the need to change their cattle rearing system to make this activity more sustainable and adapted to expanding forest and tree plantations. There is also a growing sense of interdependence among villagers and between them and forest agencies to tackle the land use conflict effectively. A second important effect deals with knowledge acquisition at both the individual and collective levels. This is illustrated by the choice of a collective management of cattle to be used in the planned joint experiment. Finally, the ComMod activities produced change in perceptions among the participants, leading to a significant improvement in the level of trust between herders and foresters. But it still needs to be reinforced through the implementation and monitoring of the agreed upon action plan.

Conclusion: further steps and improvements

The following activities aim at further improving the stakeholders' individual and collective adaptive capacity to rapid change. The implementation of the joint experiment on collective management of cattle in *ruzi* pastures established on foresters' land will be an important step toward a co-management of the forest – farmland interface in this area.

In parallel, a fully autonomous simulator is being developed to be able to simulate more scenarios in a time and cost effective way. It will also be used to respond to new requests received from the local stakeholders, such as the integration of cropping system dynamics in the simulation tool made by herders who plan to abandon cattle rearing to focus on crop production.

A local facilitator will also be identified among the motivated participants in the process and will be trained to maintain the process and monitor its impact.

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